Carters Creek Total Maximum Daily Load Implementation Project

Watershed Source Survey and GIS Mapping: Task 3

Texas Water Resources Institute TR-484
January 2016

Texas Water
Resources Institute
make every drop count

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Project Funded by:

Texas Commission on Environmental Quality: Award: 582-13-30059

Cooperating Entities:

Texas A&M AgriLife Research, Texas Water Resources Institute

Texas A&M AgriLife Research, Department of Soil and Crop Sciences

City of Bryan

City of College Station

Brazos County Health Department

Brazos County Road and Bridge Department

Texas A&M University - Environmental Health and Safety

Texas Department of Transportation – Bryan District

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Texas Water Resources Institute Technical Report TR-484

January 2016

Funding support for this project was provided in part through a Clean Water Act §319(h) Nonpoint Source Grant from the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency

Table of Contents

List of Tables

List of Figures

List of Acronyms

COCS	City of College Station
COB	City of Bryan
GIS	Geographic Information System
IP	Implementation Plan
OSSF	On-site Sewage Facility
TAMU	Texas A&M University
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
TWRI	Texas Water Resources Institute
TxDOT	Texas Department of Transportation

Project Background

The Carters Creek watershed is a tributary of the Navasota River and covers approximately 56.9 square miles in Brazos County. Of this area, 57% is urbanized (Figure 1) through development associated with the cities of Bryan and College Station. Within the Carters Creek watershed, Carters Creek, Burton Creek and Country Club Branch are all considered impaired due to elevated levels of *Escherichia coli (E. coli)*. These waterbodies were listed on the Texas Commission on Environmental Quality's (TCEQ) 303(d) list for bacterial impairments in 1999 for Carters Creek and 2006 for Burton Creek and Country Club Branch (TCEQ 2012). Each of these waterbodies was listed impaired for not meeting the *E. coli* standard for Primary Contact Recreation which is a geometric mean of 126 colony forming units (CFU)/100 mL of water. Initial listing of these waterbodies was supported by monitoring conducted by TCEQ and the Brazos River Authority (BRA).

In 2007, the TCEQ Total Maximum Daily Load (TMDL) Team began the process of developing a TMDL and TMDL Implementation Plan for the Carters Creek watershed. Watershed stakeholders were engaged in the process to develop recommendations for management measures needed to restore water quality in the Carters Creek watershed. In 2014, a TMDL was completed for each creek and as a result, they are proposed for delisting in the 2014 Texas Integrated Report (TCEQ 2014).

Through discussions with stakeholders, a recurring need expressed was for an improved understanding of the current state of the waterbodies through a watershed source survey and a monitoring effort that provides a spatially and temporally robust evaluation of water quality in Carters Creek and its tributaries.

This project was developed to fill that need through enhanced water quality monitoring and a watershed source survey. Specific project goals are to:

1. conduct extensive water quality monitoring throughout the watershed on a spatial and temporal scale that will provide additional data to identify sub-watersheds where bacteria and other pollutant contributions are problematic
2. conduct a multi-faceted watershed source survey utilizing geo-referenced field observations, and geographic information system (GIS) to identify potential sources of bacteria and other pollutant loading in the watershed
3. document watershed source survey results using GIS so that information can be integrated with available digital data on existing nonpoint and point source pollutants in the watershed
4. organize and establish a volunteer monitoring group through the Texas Stream Team program as a means to provide supplemental water quality data that will help local watershed managers further refine their knowledge of the spatial and temporal distribution of instream water quality variability

This report focuses specifically on the outcomes of Task 3: Watershed Source Survey and GIS Mapping.

Project Goals and Objectives

The objective of the watershed sources survey and GIS mapping task is to conduct a physical, ground based survey that is supported by existing GIS mapping to evaluate and identify potential sources of bacteria contribution to Carters Creek and selected tributaries. Existing GIS layers of stormwater and wastewater infrastructure from entities within the watershed were acquired and aggregated into a cohesive GIS for the watershed and surrounding area. This includes data from Brazos County, the City of Bryan (COB), the City of College Station (COCS), Texas A&M University (TAMU), and the Texas Department of Transportation (TxDOT). Additionally, land use, road networks and other pertinent information was integrated as well.

The watershed source survey component of this task resulted in the generation of new information regarding the locations and distribution of potential influences on water quality across the watershed. Watershed surveys were conducted around the watershed by volunteers and project team members as time allowed. Observations made denoted conditions observed at that location at the specific time of observation, thus they may be transient in nature and not a perpetual condition. This information was digitized and used to create GIS shapefiles that are included in the watershed GIS.

Through this task, information about potential sources of pollution throughout the watershed was developed and summarized. Potential areas of bacteria contribution were identified through this exercise and highlighted. A GIS layer of this information was also created and can be used by watershed managers across the area in planning and implementing future watershed management measures.

Physical Watershed Survey

A physical watershed survey was conducted over the course of the project by numerous individuals. A standard field survey sheet (Appendix A) was utilized for all surveys standardize the type of information reported. Surveys were conducted at each of the sites monitored throughout the course of the project. In total, surveys were completed for 127 locations along creeks and another 29 locations across the watershed. These consisted of the 13 sites monitored on a routine basis (regular schedule) over a two year period by TWRI personnel and volunteers and another 114 sites investigated for potential monitoring during the intensive sampling campaign. Some sites were surveyed more than once during the project and some surveys encompassed several of the prospective monitoring locations mentioned. Watershed sites were collected at random by TWRI staff and volunteers from the community.

During each survey of local streams, observations were made for the stream of the adjacent watershed. Stream characteristics were noted to develop general knowledge of the area and watershed characteristics were recorded to identify potential influence to water quality. Observations made at each site included garbage observed at site, presence or absence of surface runoff, presence of fecal contamination, storm drain presence and functional status, evidence of disturbed soil, animal observations, and notation of the days since the rainfall occurred. Stream characteristics focused on flow status and stream type, riparian zone and substrate material information, people seen at stream section, and any significant pools in the stream at the site. These detailed data allowed the team to develop a working understanding of each location surveyed throughout the watershed. Surveys conducted in portions of the watershed with no creek present utilized the same general approach, but did not produce any stream related characteristics. Areas surveyed in this manner included streets, roads, parks, dog parks, and areas adjacent to them.

Watershed GIS Survey

A watershed GIS was developed and served as a tool to compare watershed characteristics to water quality and explore potential relationships with observed water quality. The GIS was amassed by acquiring available GIS layers from local entities including Brazos County, COB, COCS, TAMU, and TxDOT. Statewide and national level datasets were also acquired from entities including TCEQ, Tx-

DOT, the US Geologic Survey, the US Department of Agriculture (USDA) Natural Resource Conservation Service, USDA Farm Service Agency, and the Multi-Resolution Land Characteristics Consortium. Layers were aggregated using ArcGIS 10.x software (Environmental Systems Research Institute, Inc.). Basemap layers included in the ArcGIS software utilized included the World Street Map and USA Topography Map (Table 1).

Once needed data layers from across the watershed were acquired, they were processed to create watershed specific layers. This involved merging similar files into a single file and removing data from outside of the watershed boundary. Layers created using this approach included on-site sewage facility (OSSF) locations, stormwater infrastructure, and wastewater infrastructure.

Table 1. GIS data layers and sources accessed

Data Type	Data Source
Wastewater conveyance infrastructure	City of Bryan, City of College Station, Texas A&M University Environmental Health and Safety
Stormwater conveyance infrastructure	Brazos County, City of Bryan, City of College Station, Texas A&M University Environmental Health and Safety, Texas Department of Transportation
Aerial Imagery	National Agricultural Imagery Program
Roads	Brazos County, City of Bryan, City of College Station, Texas A&M University Environmental Health and Safety, Texas Department of Transportation
City Limits	City of Bryan, City of College Station
Known OSSF locations	Brazos County Health Department
TCEQ Segments (2010)	TCEQ http://www.tceq.texas.gov/gis/hydro.html
TCEQ Permitted Outfalls	TCEQ http://www.tceq.state.tx.us/gis/sites.html
Surface Water Quality Monitoring Stations	TCEQ http://www.tceq.state.tx.us/gis/sites.html
Hydrology	USGS National Hydrography Dataset (NHD) http://nhd.usgs.gov/
Soils	United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS)
World Street Map Basemap	ESRI Online Map Service http://www.esri.com/software/arcgis/arcgis-online-map-and-geoservices/map-services
USA Toporaphy Maps	ESRI Online Map Service http://www.esri.com/software/arcgis/arcgis-online-map-and-geoservices/map-services
Land Cover	Texas A&M Spatial Sciences Lab
Land Cover	National Land Cover Dataset http://www.mrlc.gov/nlcd11_data.php

Information collected during watershed surveys was also incorporated into the GIS. Survey data was used to create a single GIS layer that includes information on the observations made for each respective survey site. This allows for survey data to be easily visualized across the watershed.

A modified approach was used to develop an estimate of OSSF locations across the county. Data available from the Brazos County Health Department was aggregated with information septage disposals made by septic pumping service companies who report the location where it originated. A method developed by Gregory et al. 2013 was also applied to identify other potential OSSFs in the watershed that may not have been noted in other data sets. Briefly, this approach combines Census data, aerial imagery and 911 address point locations to identify the number of residences in areas not serviced by centralized sewer systems. The points estimated were compared to those available from acquired data and locations where OSSFs were likely to be located but not known, were added to create an expected OSSF location layer.

Watershed Survey Assessment

The watershed survey proved to be a useful tool for exploring potential water quality influences of watershed attributes. A variety of potential bacteria sources occur across the watershed and a watershed survey is a good approach for aggregating information regarding each source type. Utilizing GIS also allows this information to be easily visualized in many cases. Availability of GIS data supported efforts to identify areas of the watershed where water quality may be adversely impacted by allowing for rapid visualization of potential water quality stressors and their proximity to local waterbodies.

Physical watershed surveys identified the presence of a variety of potential bacteria sources across the watershed. No major contributors such as illicit wastewater discharges or infrastructure failures were noted; however, a number of other items noted are likely to influence water quality across the watershed. Many observations are of transient sources that are difficult to manage.

Animals

A number of animal sources across the watershed were observed and recorded during the watershed survey process. Birds, dogs, and feral hogs or their evidence was the most commonly noted occurrence across the watershed. Other wildlife species were noted as well, but less frequently than birds or feral hogs. These findings were not surprising, but do illustrate the potential impacts that each respective source could have in the watershed.

Dog feces inside a dog park

Feral hog rooting near neighborhood and creek

Grackles roosting on powerlines

Blackbirds were the most commonly noted bird species in the watershed. The term 'blackbird' is used loosely to refer to several species including grackles, starlings, and brown-headed cowbirds. Roosts were observed in multiple locations around the watershed; most often associated with large parking lots. Roosting locations were not consistent though as store owners routinely enact measures to deter the birds. Depending on the location of the birds, they can have considerable potential to contribute bacteria to nearby water bodies following rain events. Cliff swallows were also noted to occur under several bridges in the watershed during summer months, but were not present in large numbers. Bridges in rural areas typically had larger numbers of birds present than urban bridges. When present, it has been demonstrated that these birds can significantly impact instream bacteria concentrations under normal or low flow conditions (Pendergrass et al. 2015). Cliff swallows are migratory thus their potential influence is variable spatially and temporally. Locations in the watershed were concentrated bird evidence was observed are identified in Figure 1.

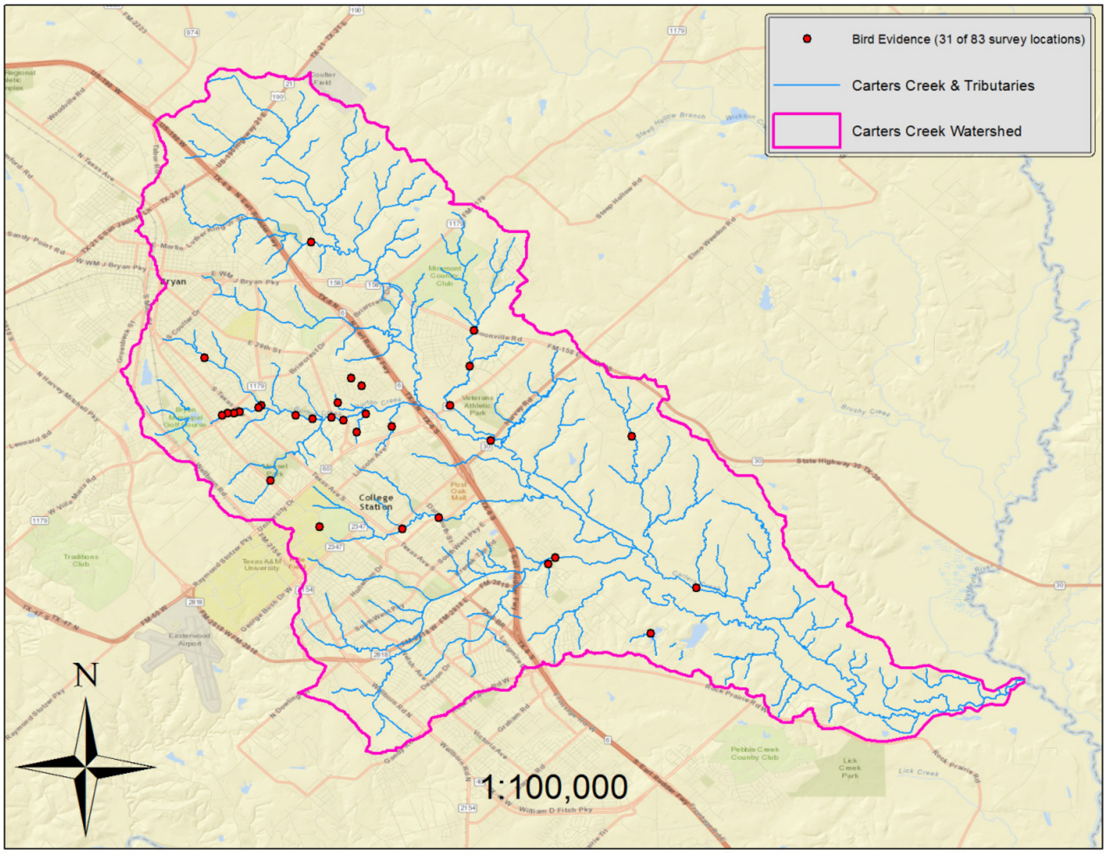

Figure 1. Locations where bird evidence was observed

Dogs were also noted to be a common source of fecal matter identified across the watershed (Figure 2). Parks and dog parks were identified as areas with a high incidence of dog feces present. Many parks did have pet waste stations present, but no waste bags were available. Posted rules in parks regarding pet waste mandate the proper collection and disposal of waste, but they are routinely ignored. The proximity of many parks to waterbodies intensifies the potential for fecal matter present to travel to the stream during a runoff event. Random dog defecation along city streets was also observed. This occurred primarily in residential neighborhoods and is presumably caused by dog owners not disposing of pet waste left during walks.

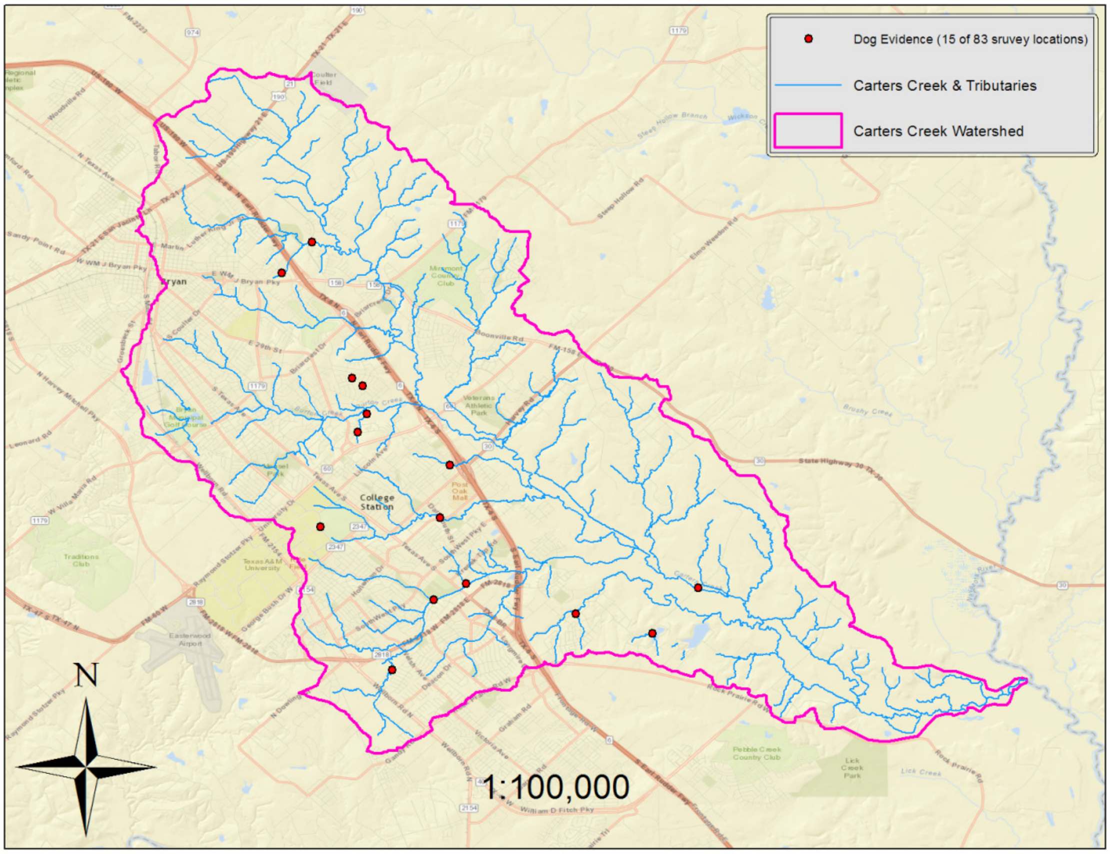

Figure 2. Locations where dog evidence was noted

Mammalian wildlife, or their evidence, was also noted in many locations across the watershed (Figure 3). Feral hog evidence including rooting, tracks and feces was observed in multiple locations but was contained to riparian areas in both rural and urban portions of the watershed. Numerous other urban wildlife identified across the watershed include coyotes, deer, opossums, raccoons, rabbits, skunks, and squirrels. Their influence on water quality is thought to be relatively small compared to other species; however, they do contribute to the overall *E. coli* load in the watershed.

Livestock are present in the watershed and primarily include cattle and horses in undeveloped areas of the watershed. In some locations, they are pastured adjacent to the creek, but no commonly used access points to the creek were observed during the survey. Creek access is limited by fencing in some locations thus minimizing the impacts that livestock have on in stream water quality. Livestock numbers are generally declining across the watershed as development increases. The noted occurrence of livestock in the watershed was not mapped.

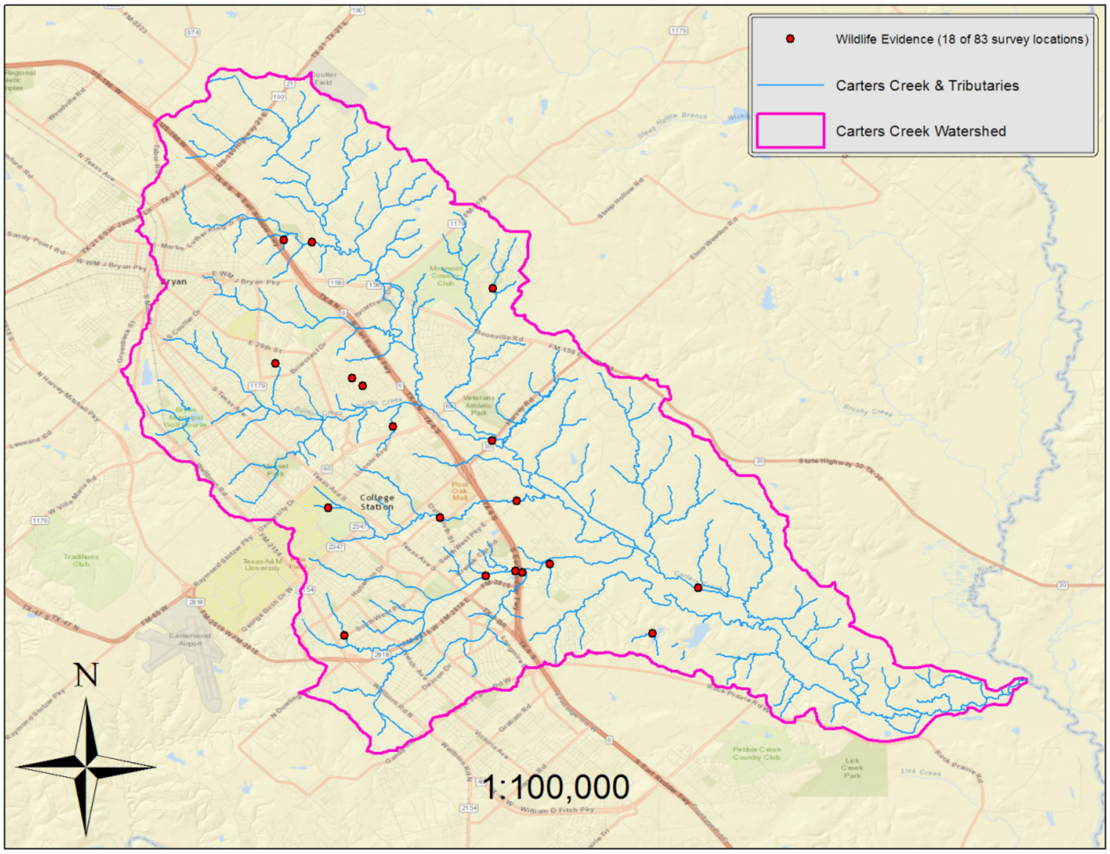

Figure 3. Locations where wildlife evidence was noted

Garbage

Garbage was commonly found in many areas of the watershed; especially in creek channels and riparian areas. This is not uncommon as wind routinely transports small, light-weight garbage across the watershed until it is trapped or leaves the watershed completely. Large or heavy garbage is less mobile and its presence is typically the result of direct dumping. Riparian areas often trap garbage in the vegetation and hold it until a flood event washes it down stream. Stream channels also retain garbage until it is moved downstream by water since they are the lowest point in the area and are not effected by wind. Garbage is not necessarily a source of *E. coli*, but its presence is certainly not good for water quality, aquatic life or aesthetics. Figure 4 depicts areas in the watershed where garbage was observed and provides information on its size and type.

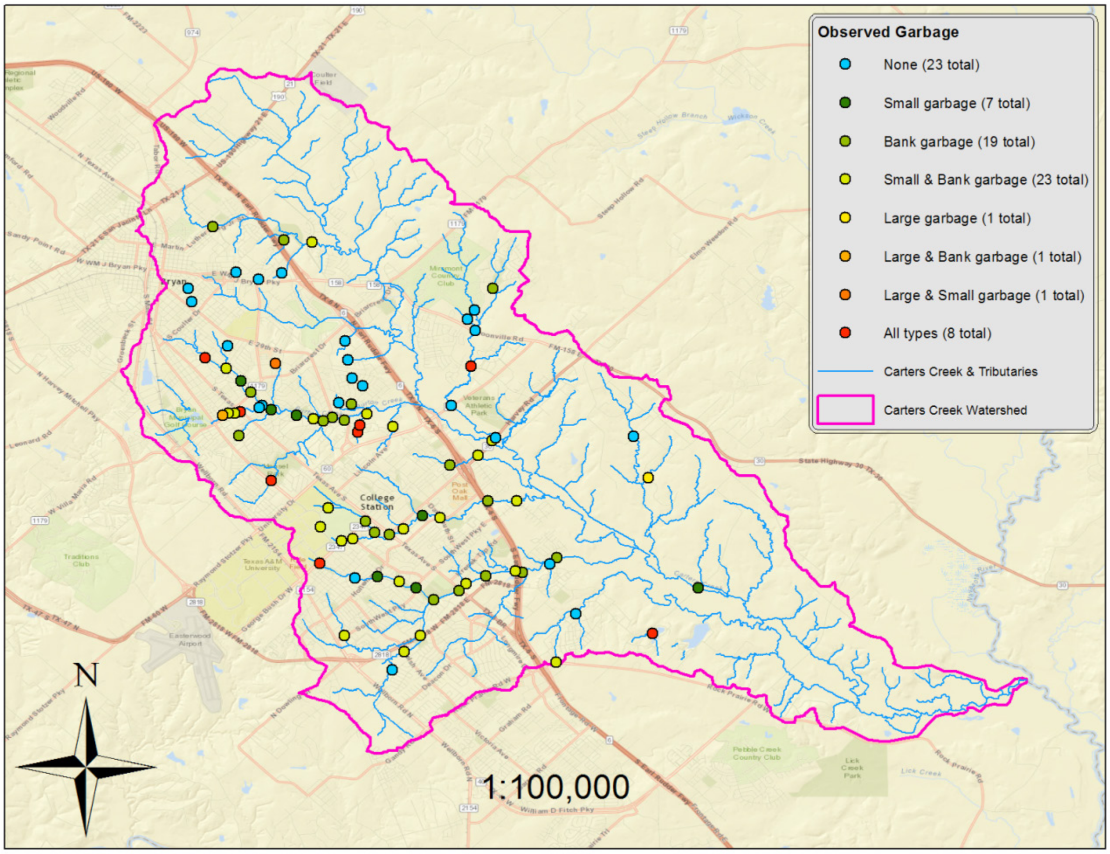

Figure 4. Survey locations with observed garbage and garbage type

Infrastructure

Various types of infrastructure across the watershed were noted to have potential influences on in-stream water quality. Bridges and road crossings, stormwater conveyances and wastewater infrastructure all have potential to contribute *E. coli* to the creek due to their direct interactions; however, the influence of these sources can be minimized.

Roads that intersect streams are not necessarily a source of *E. coli*, but they do provide a potential avenue for *E. coli* to enter the waterway. Roads and other impermeable surfaces produce large volumes of runoff compared to lawns, pastures, or other more natural surfaces and thus have the potential to rapidly transport *E. coli* into the stream through the curb and gutter system or other associated stormwater conveyances. In total, 433 road and stream intersections were identified within the Carters Creek watershed (Figure 5). Road crossings are naturally associated with development and occur more frequently inside the city limits of Bryan and College Station than in the unincorporated areas of the watershed.

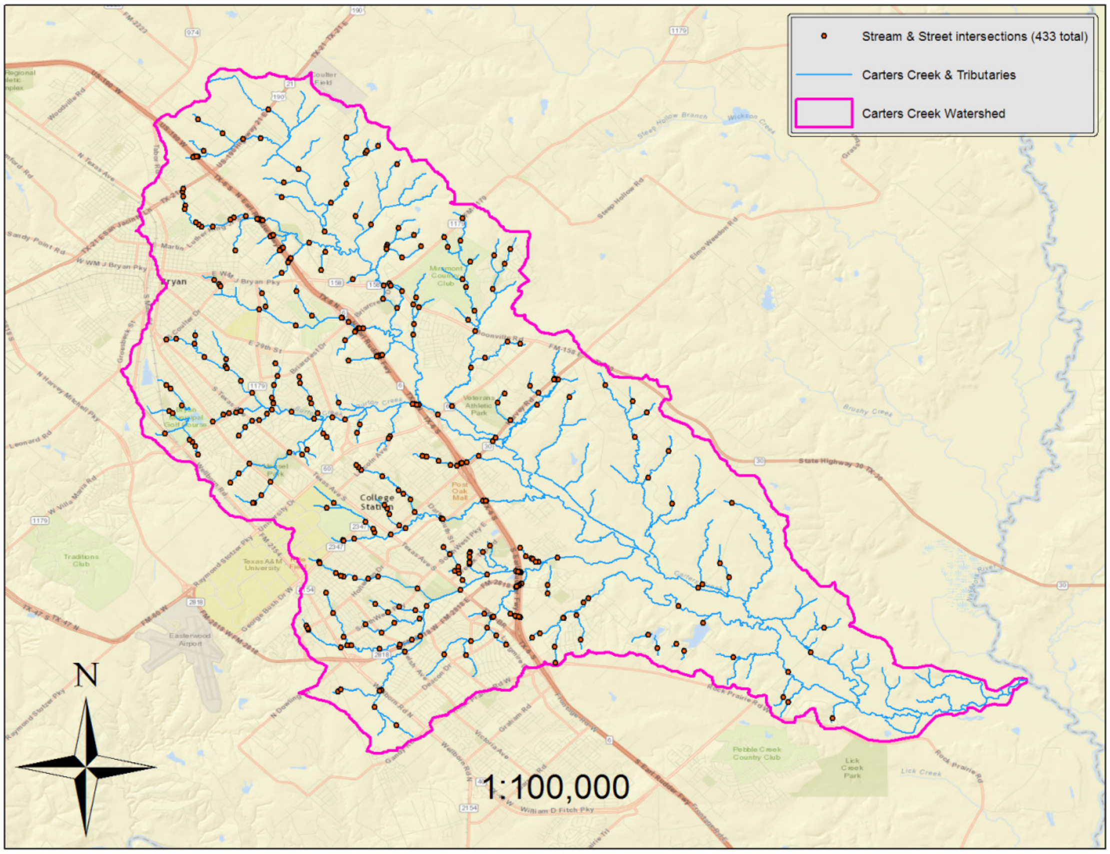

Figure 5. Locations where street crosses a defined stream in the watershed

Stormwater conveyance infrastructure also has the potential to impact instream *E. coli* levels. Surface infrastructure such as road curbs and gutters, grass ditches and management features such as detention ponds, settling basins and others all collect and direct the movement of surface water through the watershed. As this water moves, it carries *E. coli* and other pollutants toward the stream. Underground infrastructure is also vital to the larger stormwater network and is routinely used to drain streets, parking lots, and other types of development. This infrastructure is critical for protecting property through the safe transmission of excess runoff from the watershed. A total of 713,200 feet of subsurface stormwater conveyance infrastructure was identified within the watershed during the watershed survey (Figure 6). This measurement does not include culverts.

Stormwater inherently contains elevated *E. coli* concentrations; however, storm drains can also contribute water to stream between runoff events. Excess landscape irrigation or illicit connections can occur and provide a relatively consistent source of water to stormwater infrastructure. In some cases, wastewater entering stormwater infrastructure has been identified as primary contributors of *E. coli* to receiving waters between storm events (Sercu et al. 2009; Ekklesia et al. 2015). Stormwater infrastructure also retains sediment known to harbor *E. coli*. Pipes that protect sediment from sunlight and decrease drying can promote prolonged *E. coli* survival and regrowth in sediment in some cases (Smith et al., 2008; Pachepsky et al. 2011). As a result, stormwater infrastructure should be considered as a potential source of *E. coli* contributions to watersheds during wet and dry conditions. Sediment in stormwater outfalls was noted in some locations and could be a potential *E. coli* reservoir in the watershed.

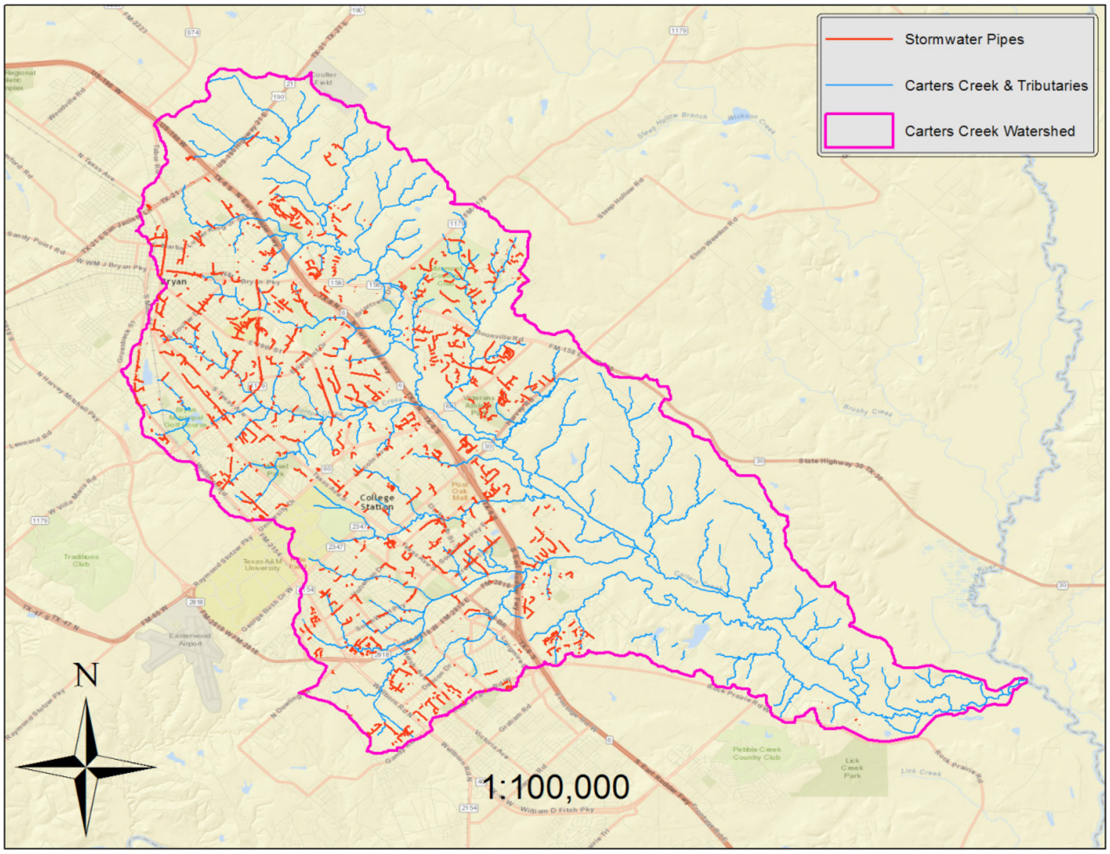

Figure 6. Underground stormwater conveyance infrastructure

Sediment in Storm Drain Outlet

Storm Drain Outlet and Adjacent Wastewater Line

Wastewater infrastructure is another potential source of *E. coli* in the watershed. When functioning properly, wastewater infrastructure effectively transports waste to treatment facilities where it is properly treated. Disinfected effluent is then discharged to local creeks and should not increase *E. coli* concentrations significantly. However, failures within the wastewater conveyance and treatment system can occur. System age, accidents and natural conditions such as extremely wet or dry weather are possible causes of these failures. Proximity of infrastructure to creeks increases potential for wastewater infrastructure failures to impact instream water quality. Over 2,515,000 feet of wastewater conveyance lines are in the watershed and 468 intersections of these lines and stream channels occur. Of the wastewater infrastructure observed, no failures were noted.

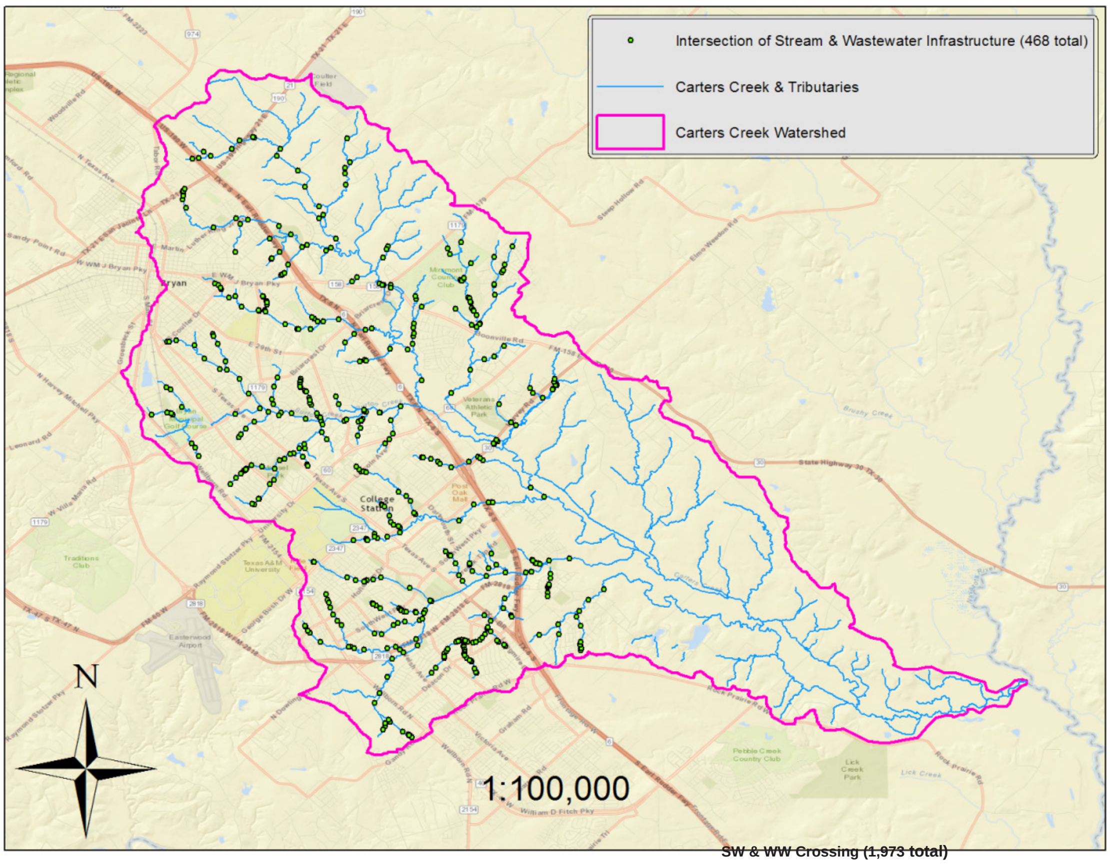

Figure 7. Points where wastewater infrastructure intersects a stream

Potential interactions between stormwater and wastewater infrastructure have been identified as a significant source of *E. coli* in many watersheds (Ekklesia et al. 2015; Sercu et al. 2009). Illicit connections of wastewater lines to stormwater infrastructure have been identified as sources of *E. coli* in some cases while failures in both wastewater and stormwater infrastructure that allow wastewater to move into stormwater conveyances have been implicated in other areas. No occurrences of this nature were identified in the watershed; however they could potentially occur. The watershed GIS survey allowed points were known wastewater collection lines and underground stormwater conveyance lines cross each other to be mapped. These points are not connections, but instead represent locations where one line crosses over the other. Potential for interactions between the separate infrastructure systems is greater at or near these points. In total, 1,973 locations were wastewater and stormwater infrastructure cross were identified in the watershed (Figure 8).

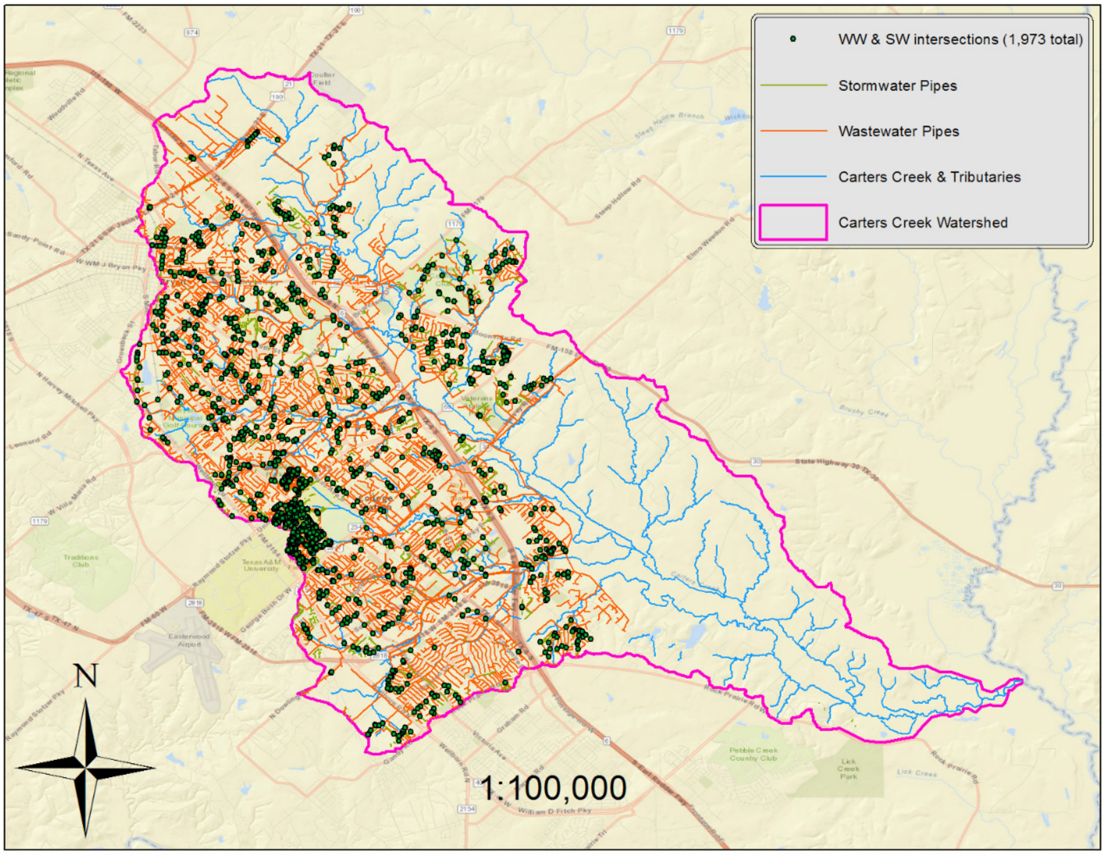

Figure 8. Locations where stormwater and wastewater infrastructure conveyances cross each other

On-Site Sewage Facilities

Rural areas often rely on OSSFs to treat and dispose of household wastewater. When properly designed, installed, operated and maintained OSSFs provide cost effective treatment of human waste that mitigates the release of *E. coli* to the environment. As with any management system, failures can and do occur as a result of system age, improper maintenance, poor system installation or design, or system overload. Regardless of cause, failures increase the potential for wastewater to be released to the environment without proper treatment. Proximity of a failing OSSF to creeks or drainage ditches can influence the potential for improperly treated waste to make its way into downstream water bodies. Much of the Carters Creek watershed receives centralized wastewater service provided by the cities of Bryan and College Station or TAMU and does not rely on OSSFs. However, the entire watershed is not completely within the cities' respective wastewater service areas. This includes the unincorporated areas of the watershed and some neighborhoods in recently annexed portions of the city. In total, there are an estimated 769 OSSFs distributed across the watershed (Figure 9).

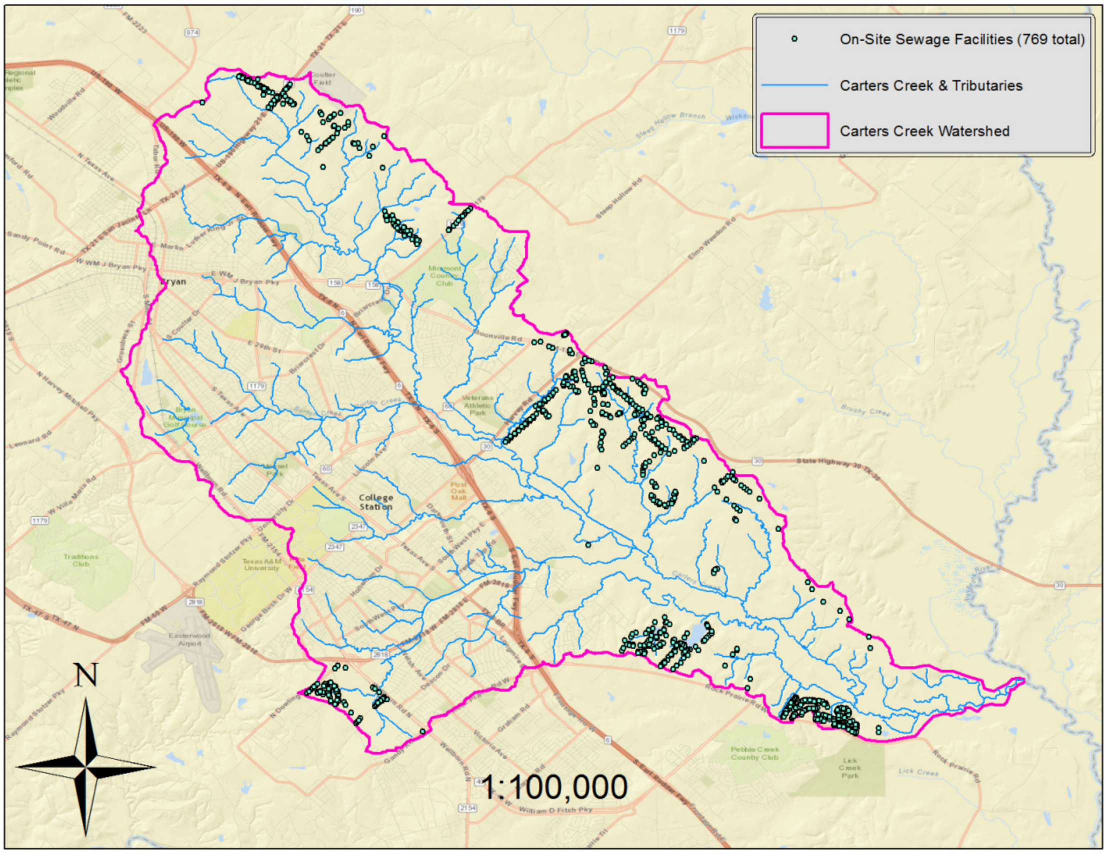

Figure 9. Estimated OSSF locations in the Carters Creek watershed

Land Use and Land Cover Assessment

Land use and land cover is a major factor driving water quality and watershed processes. Land cover changes are often associated with changes in water quality. Generally, as the level of impervious surface increases, water quality degrades. This is due to multiple factors such as the concentration of potential pollutant sources, increased runoff production, and decreased water filtering and storage capacity of the watershed. From a bacteria perspective, water quality is generally best in watersheds with very little disturbance such as forests and gradually degrades as the level of use increases and the quantity of natural cover decreases (Goto and Yan 2011).

Changes in land use and land cover in the watershed have increased considerably in recent years due to the rapid growth of Bryan and College Station and the surrounding areas. Land use and land cover layers from 2001 and 2011 were compared to quantify this level of change. This assessment demonstrated considerable loss of open space and a considerable increase in developed areas (Table 2, Figure 10). Collectively, 8.5% of the watershed area experienced a land use change in this 10 year assessment window. The largest categorical losses occurred in forests, shrub/scrub and in pastures. Increases in developed land accounted for the losses with all categories of development seeing increases. However, some of the development in the watershed simply moved from one development category to the next. For instance, some developed open space areas were redeveloped and are now considered medium or high intensity development. These changes are illustrated in the bottom panel of Figure 10 which depicts the areas of the watershed where land use change actually occurred.

Table 2. Carters Creek land use change between 2001 and 2011

Land Use and Land Cover Classification	Acreage Totals in Assessment Years		Difference between Assessment Years*
	2001	2011	
Open Water	118.5	124.8	6.2
Developed, Open Space	6,200.4	6,258.0	57.6
Developed, Low Intensity	6,131.9	6,553.1	421.2
Developed, Medium Intensity	5,125.3	6,071.4	946.1
Developed, High Intensity	1,476.5	1,898.8	422.3
Barren Land	79.2	68.9	-10.2
Deciduous Forest	3,546.3	3,035.7	-510.6
Evergreen Forest	136.8	109.2	-27.6
Mixed Forest	1,232.5	1,148.2	-84.3
Shrub/Scrub	3,026.6	2,501.5	-525.1
Grassland/Herbaceous	691.0	700.1	9.1
Pasture/Hay	6,307.6	5,686.8	-620.7
Cultivated Crops	211.9	210.8	-1.1
Woody Wetlands	2,052.3	1,957.7	-94.5
Emergent Herbaceous Wetlands	91.6	103.2	11.6
*positive values denote an increase in acreage between years and negative values denote a loss			

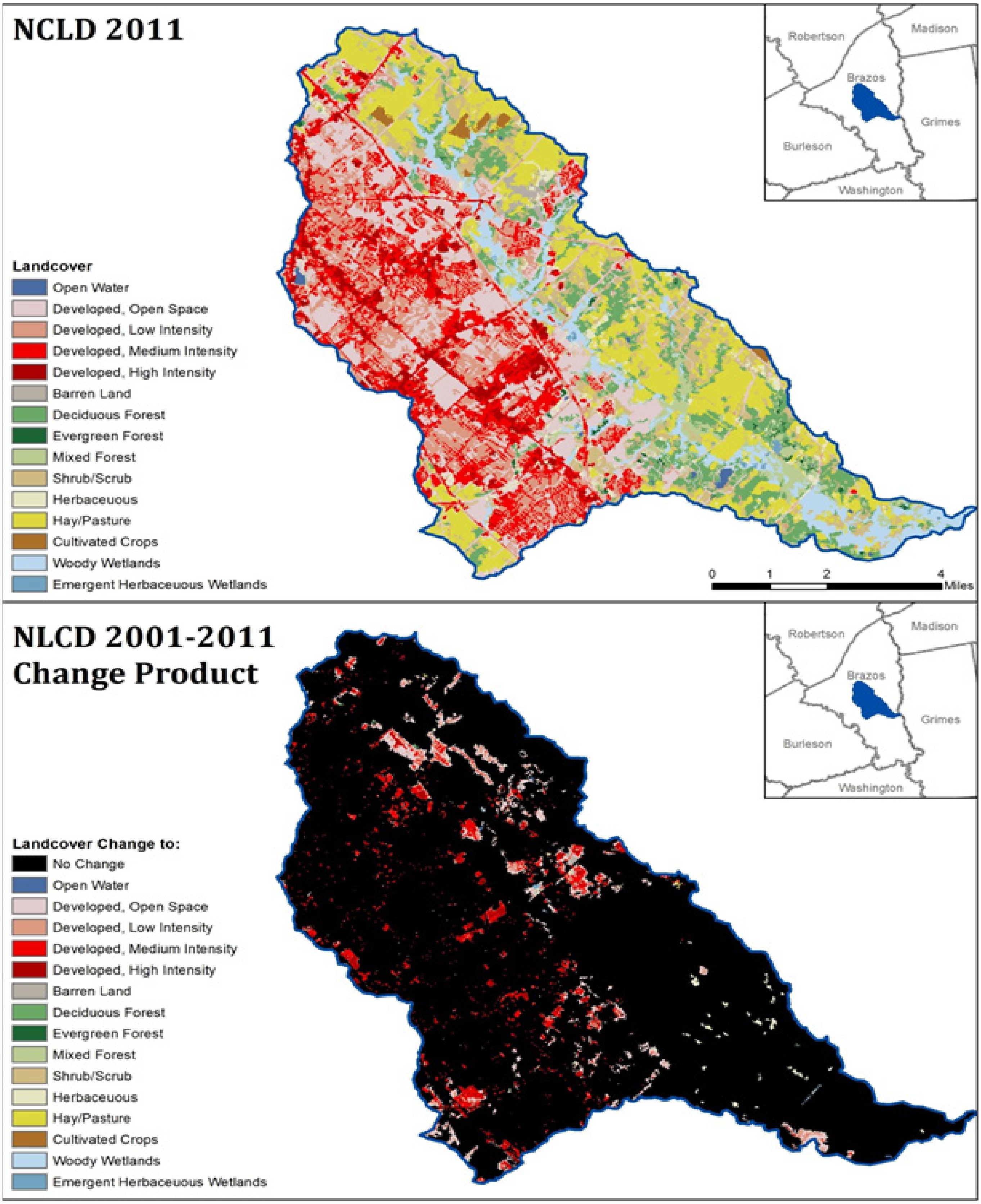

Figure 10. Land use and land cover (top) and the area where land use and land cover change occurred (bottom) in the Carters Creek watershed

Discussion and Conclusions

Completion of the watershed survey and GIS development provided beneficial supplemental information that allowed potential causes and sources of *E. coli* contribution across the watershed to be evaluated. No obvious *E. coli* source contributions were identified through this watershed survey, but useful information was generated that can inform future infrastructure inspection and maintenance planning. Evaluating available water quality data and comparing the results to information contained within the survey can illustrate areas where further investigation is needed to identify potential water quality stressors.

While survey results are useful, many of the items documented through the physical watershed survey do not provide discrete evidence of *E. coli* sources in the watershed. Animal sources are of particular importance as many of them are free to move around the watershed. Wildlife species such as birds, feral hogs and others are transient and move roosting/bedding locations on a routine basis. Similarly, food resource availability changes throughout the year and has significant influence on the area utilized by these species. As a result, the information reported here regarding the occurrence of wildlife should be used for informational purposes only. A more appropriate approximation of were wildlife may occur can be derived by looking at land uses and land cover.

Seemingly static information presented in the survey may also provide incomplete information regarding the true distribution of the respective dataset. Rapid growth and redevelopment of many areas of the Carters Creek watershed is leading to new stormwater and wastewater infrastructure being rerouted or installed on a daily basis rendering the layers included in the GIS obsolete. However, each entity has full-time staff dedicated to mapping their respective infrastructure and they do an excellent job keeping their files up to date and available to their respective entity staff for planning future management.

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Appendix A: Survey Field Data Form

Carter Creek Watershed Survey Field Data Form

PLEASE PRINT (Black Ink)

Monitor's Name:

Phone: Email:

Survey conducted from X to Y location:

Orientation (direction): Facing

Site ID:

Date (MMDDYYYY): Time Spent Sampling (hh:mm)

Watershed Characteristics

1. Garbage Observed in area

	Absent	Rare	Common	Abundant
Large garbage	☐	☐	☐	☐
Small garbage	☐	☐	☐	☐
Creek Bank garbage (if applicable)	☐	☐	☐	☐

Briefly describe garbage observed: ______________________________

2. Is there any surface runoff present at time of inspection

☐ No ☐ Rain runoff ☐ Irrigation runoff ☐ Other ______________________________

3. Check for evidence of potential sources of fecal contamination in watershed (check all that apply)

☐ Dog ☐ Wildlife
☐ Bird ☐ Feral hog signs; if so, what ______________________________
☐ Livestock ☐ Type of evidence ______________________________

4. Is a storm drain present on the street (check all that apply)

☐ No ☐ If yes, is a drain marker present? ☐ Yes, with grate ☐ Yes, no grate ☐ Debris in drain ☐ N/A

5. Is there any disturbed soil in the area

☐ No ☐ Bare lot ☐ Construction ☐ Sediment from yard

6. Animals present?

☐ No ☐ Yes If so, what ______________________________

7. Days since last rainfall ______________ ☐ Don't know

Stream Characteristics (If present)

8. Check the following channel flow status

☐ Dry ☐ Low Flow ☐ Normal ☐ High ☐ Flooded

9. Check the flow stream type that applies on the day of the survey

☐ Ephemeral; stream flow only during/shortly after rainfall, contains no refuge pools capable to sustain community
☐ Intermittent; a stream which has zero flow for at least one week during most years
☐ Intermittent w/perennial pools; intermittent stream which maintains persistent pools even in low flow
☐ Perennial; a stream which flows continuously throughout the year

10. Riparian Zone (Mark dominant categories with L (left bank) and R (right bank) as facing downstream)

N/A	Forest	N/A	Urban	N/A	Rip Rap (large rocks for bank protection
N/A	Shrub dominated corridor	N/A	Pasture	N/A	Concrete
N/A	Herbaceous marsh	N/A	Row Crops	N/A	Other: ______
N/A	Mowed/maintained corridor	N/A	Denuded/Eroded Bank	☐	

11. Substrate Material (check all that apply)

☐ Cobble ☐ Gravel
☐ Sand ☐ Bedrock
☐ Silt ☐ Rip Rap
☐ Mud/clay ☐ Concrete
☐ Unable to determine

12. Are there people using this section of the stream? Eg. Swimming, fishing, rope swing, vehicle tracks in streambed, boats

☐ No ☐ Yes, then explain: ______

13. Are there significant pools (greater than 10m (32ft) in length)?

☐ No ☐ Yes, then how many and largest size: ______

14. Comments/Observations*:

______

______

______

______

______

______

______

*Please take photographs and make note of the orientation. Email photographs to matthew.brown@ag.tamu.edu
eg. Facing N on Texas Ave. at intersection of Texas Ave and Univ Dr.